# THE EXPLOSIVES ENGINEER

REG. U.S. PAT. OFF.

Forerunner of Progress in Mining, Quarrying, Construction

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**Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.**


Along the southern coastline of Connecticut, 45 contracting firms are working at 48 different locations to complete the 129-mile Greenwich-Killingly Expressway. This modern highway starts near Port Chester at the New York State line, extends in a northeasterly direction, and ends at the Rhode Island State line. Scheduled for completion in the summer of 1958 at a cost approximating $445 million, it is the most ambitious public service project ever sponsored by the Connecticut State Highway Commission.

Most of the right-of-way will be 300 ft. wide; however, at some locations this will be expanded to 450 ft. while at others it will be limited to 180 ft. The lanes will be 12 ft. wide with paved outside shoulders 10 ft. wide.

In addition to the actual construction work on the Expressway, another large program involves the erection of 283 bridges and viaducts.

Between Greenwich and Fairfield, the work on the roadway includes a great deal of blasting with explosives. Much of the right-of-way in this area goes through built-up, congested parts of towns, residential and suburban sections, and, for some distance, parallels the main line of the New York, New Haven, and Hartford Railroad.

The article beginning on page 72 reviews some of the important operating details on this big highway job.

* * *

Six miles below the famous cataracts of Niagara Falls, on the Canadian side of the 300-ft. cliff of the lower Niagara River gorge, the building of a new generating station for the Hydro Electric Power Commission of Ontario is nearing completion. The work involved in the construction of this new generating station, together with its twin tunnels, ten shafts, canals, and forebays, represents one of the important engineering feats to be accomplished in North America.

The water required to operate the new station will be sent through two parallel tunnels, each 5½ miles long and an unfinished diameter of 51 ft., driven through rock under the Canadian city of Niagara Falls. The driving of the tunnels required the blasting and excavating of 4,375,000 cu. yd. of rock.

Of unusual interest was the method of benching the floor of a top heading to invert grade. A special jumbo, designed and built by Perini-Walsh and Associates, was used. Its success resulted in its being adopted for use in all sections.

A description of what had to be done and how it was done will be found in the article beginning on page 81.

* * *

In laying a 30-in. pipeline across the 4,700-ft.-wide Susquehanna River near Delta, Pennsylvania, the contractor introduced a new unit that made possible the use of pneumatic rock drills to make shot holes in the bed of the stream. The unit, called "Susquedriller," represents one of the outstanding innovations in recent years for the technique of laying pipe across a rocky river.

The blasting operations called for a five-spot drilling pattern using three rows of holes, each 10 to 11 ft. deep. The holes in the two outside rows were spaced 5 ft. apart. Holes in the inside row were staggered, using the same spacing. There were 3,123 holes drilled and blasted in 34 days.

The holes were loaded with 3 by 12-in. cartridges of 80% gelatin primed with Primacord*. Results were uniformly satisfactory and no secondary blasting was required.

A summary of the equipment and operating methods used is given in the article beginning on page 87.

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company


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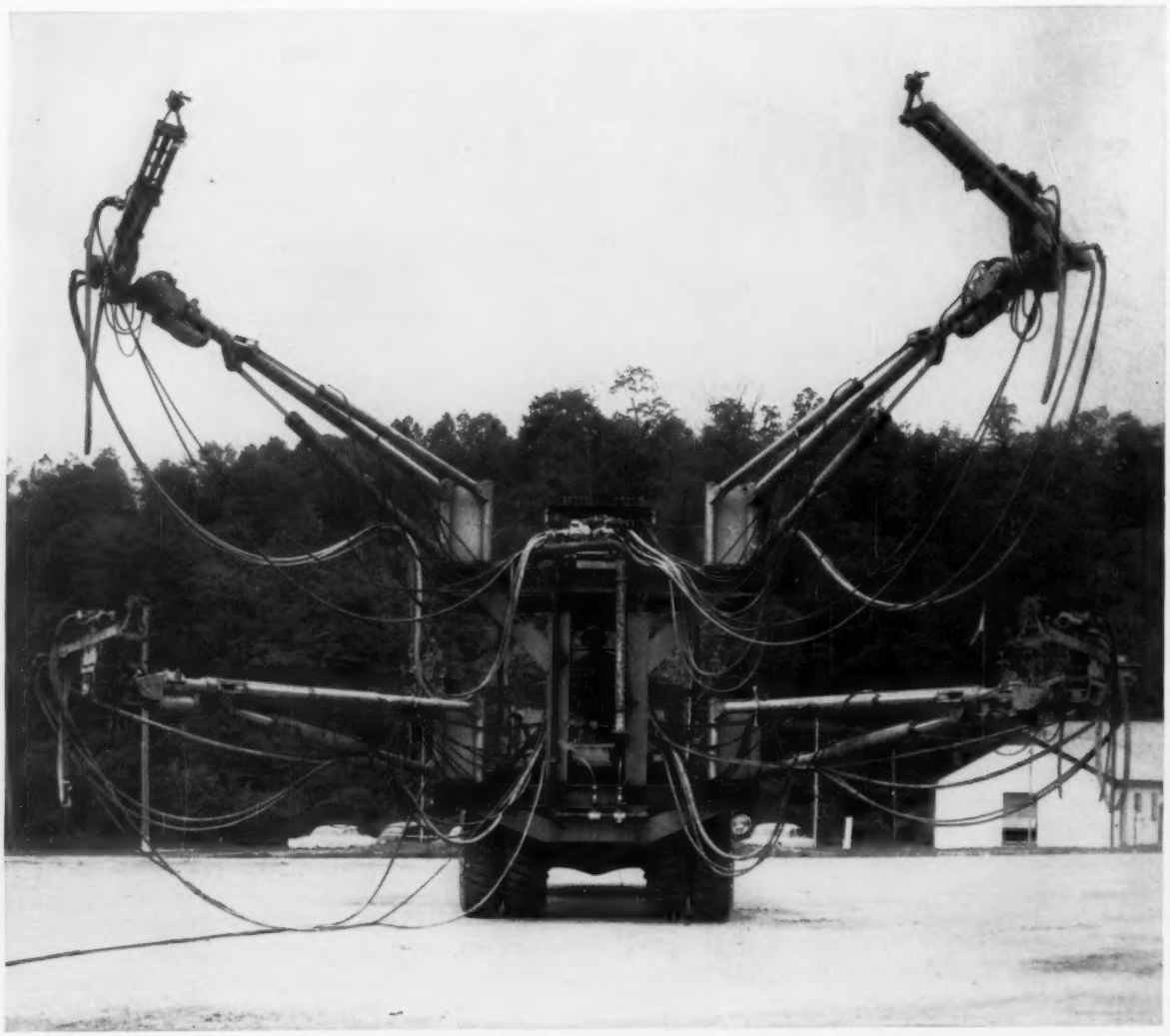

Head-on view of a 4-boom jumbo. Note wide reach of the Gardner-Denver hydraulic booms.

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# GARDNER-DENVER COMPONENTS

Tailor your truck, tractor or rail mounted jumbo with Gardner-Denver booms, feeds and drills. You get just what you need for each dollar invested. Gardner-Denver offers a wide selection in:

- **HYDRAULIC BOOMS,** completely automatic and remotely controlled for mounting on your jumbo.
- Manufactured in two sizes and types (tunnel and rugged types), TRIPODS for mounting heavier drifter equipment with the longer chain feed.
- **POWERFUL ROCK DRILLS** in 3-, 3½-, 4 and 4½-inch sizes. Long chain or screw feed mountings.
- **SECTIONAL DRILL RODS** and couplings for long-hole drilling. Gardner-Denver Ring Seal Shank.
- **REMOTE CONTROLS** located at any point along the boom or on the jumbo chassis. With G-D Remote Controls, one operator moves booms into position and controls complete drilling operation without leaving his station.

Gardner-Denver engineers will work with your staff and powderman to design your jumbo to the job.

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# EXPLOSIVES RESEARCH PAYS OFF

The construction of modern highways utilizes many and varied engineering skills and techniques. One of these skills, the use of specialized explosives and blasting methods, helps to speed completion of these arteries so important to our economic development.

The efficient use of industrial explosives levels hills, fills valleys, drives tunnels, and straightens rights-of-way to make the highways of tomorrow wider and safer.

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HERCULES

MAJOR GENERAL EMERSON C. ITSCHNER

# Emerson C. Itschner

MAJOR GENERAL, UNITED STATES ARMY

CHIEF OF ENGINEERS

## A Biography

WHEN President Eisenhower appointed Major General Emerson C. Itschner as Chief of Engineers, United States Army, on August 10, 1956, he chose one of the youngest officers ever appointed to that post. The President's choice is a man eminently qualified for this important assignment by reason of educational background, broad experience in military and civic affairs, exceptional administrative ability, and an unusually attractive personality.

Emerson C. Itschner was born in Chicago, Illinois, July 1, 1903, the son of Charles and Lucrecia (Burns) Itschner. He received his elementary education at Norwood Park Elementary School in Chicago and completed the high-school course at Carl Schurz High School, Chicago. He immediately entered the United States Military Academy at West Point and was graduated in 1924 with a Bachelor of Science degree.

Following his graduation from West Point, the young officer began his long and eventful career with the Army's Corps of Engineers. As a second lieutenant, he received his first assignment with Company B, 13th Engineers, at Fort Humphreys, Virginia, now Fort Belvoir. In 1925, he was sent to Cornell University where, after one year, he was awarded a degree in civil engineering. He returned to Fort Humphreys and entered the Engineer School for the 1926-27 term. His next assignment was with the Alaska Road Commission in Fairbanks, Chitina, Juneau, and elsewhere in Alaska, where he remained until 1929.

From 1929 to 1932 he served as commanding officer, Company A, 6th Engineers, at Fort Lawton and Fort Lewis, Washington. During the next four years he was at the Missouri School of Mines at Rolla, teaching military science and tactics.

From 1936 to 1937 he was assistant to the division engineer, Upper Mississippi Valley Division, St. Louis, Missouri. The next two years he was assistant to the St. Louis District engineer. From 1939 to 1940 he was assigned to the Command and General Staff School at Fort Leavenworth, Kansas, for advanced studies.

After a few months in 1940 with the 10th Engineer Battalion and the 3rd Division, Camp Ord, California, he was made commanding officer of Company A, 29th Engineer Battalion, at Oceanside, California.

Shortly before the entrance of the United States in World War II, General Itschner was ordered to Washington, D. C., to become assistant and, later, chief of the Air Force Construction Section in the Office of the Chief of Engineers. He remained in charge of this section for the Chief of Engineers in the early part of World War II, when the Air Force construction program was at its height. In July, 1943, General Itschner was sent to the European Theater of Operations, where as engineer of the Advance Section Communications Zone, he was responsible, among other things, for heavy construction within the areas through which the armies entered Northern France. With the termination of European hostilities, he was assigned to the Philippines as base commander.

When World War II was ended, General Itschner was returned to Washington and served three years as chief of the Military Construction Operations Division in the Office of Chief of Engineers. From 1949 to 1950 he was district engineer at Seattle, Washington.

In September, 1950, General Itschner was named engineer of the First Corps and served fourteen months in Korea during the period of rapid advance to the Yalu River and the subsequent withdrawal. He was in charge of the demolition of military structures and installations in both the North and South Korean capital cities.

In April, 1952, General Itschner was assigned to Portland, Oregon, as North Pacific Division Engineer. He was responsible for the civil and military programs of the Corps of Engineers in Oregon, Washington, Idaho, Western Montana, and Alaska. He remained at Portland for eighteen months when he was returned to Washington, D. C., as Assistant Chief of Engineers for Civil Works. His appointment by the President as Chief of Engineers became effective October 1, 1956.

Emerson C. Itschner married Eleanor Corey on January 30, 1932, in Seattle, Washington. They have three daughters: Eleanor Ann, Gail Sandra, and Carol Vine. The family home is at 505 Tyler Place, Alexandria, Virginia.

General Itschner is a member of the Society of American Military Engineers, American Society of Civil Engineers, Washington Society of Engineers, Permanent International Navigation Congress, and Newcomen Society. Among his decorations are the Legion of Merit with three Oak Leaf Clusters, the Bronze Star Medal, the Air Medal, and the Purple Heart.

Although many and varied responsibilities, including a heavy travel schedule, leave little time for relaxation, General Itschner finds opportunities to indulge his two principal hobbies – playing tennis and working in his garden.

# Editorial

## Lock Up Your Caps So Kids Can't Get Them

Why are there accidents to children from playing with blasting caps? The answer is relatively simple: Caps have been left where children can pick them up, and everyone is familiar with the exploratory genius of children.

Summer vacation months from school are with us again and thousands of children will spend more time out-of-doors. At that time, and in every section of the country, work on highways and heavy-construction jobs, in rock quarries, and in mines will be at the peak. The operations at these locations will require the use of large quantities of blasting caps. These circumstances multiply the possibilities of accidents to our boys and girls from playing or tinkering with blasting caps.

### A Never-Ending Campaign To Alert the Public

During the past 31 years, the Institute of Makers of Explosives, an association of manufacturers in the United States, has conducted an intensive campaign to alert the public to the dangers to children from playing with blasting caps. It has sent posters to schools throughout the country, warning the children. It has shown them pictures of blasting caps and the damage they can do. It has sent letters to news editors, policemen, and firemen, together with special scripts and films to directors of radio and television stations, asking for aid in getting its messages to children. It has rallied the support of many agencies and societies of the nation to combat these tragic happenings. The cooperation received all along the line has been magnificent.

The Institute has prepared leaflets for users of dynamite and blasting supplies, urging them to keep their stocks under lock and key at their places of work. For many years, circulars have been enclosed in shipping cases and cartons in which dynamite and blasting caps are transported, as reminders of the danger of leaving explosives lying around mines, quarries, or construction projects.

### Thorough-Going Cooperation Will Eliminate These Accidents

With more blasting caps being used in industry and more children in the affected age group this year, it will be a bigger job than ever before to keep blasting caps away from children. But, it can be done. With thorough-going cooperation all along the line, especially by those who handle and use industrial explosives, these pitiful accidents to our boys and girls can be eliminated.

From the results obtained to date from this never-ending campaign it is evident that the problem continues to be largely one of education. The efforts of the Institute in this direction can be supplemented to an invaluable degree by the cooperation of parents and supervisors of children's activities as well as the utmost care on the part of those responsible for the storage and use of blasting caps.

A decade or so ago, there were hundreds of blasting-cap accidents to children each year. Largely through the program initiated by the Institute, such accidents have been markedly reduced in recent years. Although this was a major accomplishment, with the growing use of industrial explosives and the increase in child population, the Institute feels redoubled efforts are necessary. Even a single injury to a child from a blasting cap is one too many.

### Get Copies of the New Movie and Poster

The Institute recently prepared for public distribution a 16-mm. motion picture in color titled "Blasting Cap — Danger." This 15-minute film has been shown to children in schools, churches, scout meetings, and similar group assemblies. The movie tells a story that grips and holds the attention of the audience and presses home the warning.

On the opposite page we have reproduced a newly designed poster provided by the Institute. It is an urgent plea to anyone who works on a job where dynamite and blasting caps are used.

Requests for copies of the new poster and for prints of the new sound-and-color movie should be addressed to Institute of Makers of Explosives, 250 East 43rd Street, New York 17, New York.

Are your blasting caps kept safely removed at all times from the hands of kids who want to have a little fun? Prepare now for the summer vacation months. Make it your business to know that everyone who handles, stores, or uses blasting caps is obligated to exercise extreme care in preventing them from getting into the hands of boys and girls.

Lock 'em up so kids can't get them.

# LOCK THEM UP!

so kids can't get HURT!

# Connecticut's GREENWICH-KILLINGLY Expressway

**Beginning at the New York State line and extending for 129 miles along the shoreline, the new superhighway will revolutionize traffic conditions in southern New England**

A. J. CALLAHAN*

THE southern coastline of Connecticut is a beehive of construction activities as 45 contracting firms are working at 48 different locations to complete the 129-mile Greenwich-Killingly Expressway. It is the latest and, perhaps, the most ambitious public service project ever sponsored by the State's Highway Commission.

Since colonial times, the Post Road, known officially as Route U.S. 1, has been the main artery of east-west vehicular travel between New York and the cities and towns of southeastern New England. The rapid expansion of automobile passenger and truck traffic created a serious bottleneck along the route. The opening of the Merritt Parkway in 1940 afforded some relief for this traffic-congested situation. But, the constant increase in automobile travel has made the Parkway inadequate.

Several years ago, Connecticut's Highway Department began a series of studies and surveys to find a solution to the traffic problem in the area. The surveys developed that during 1957 the traffic each day on the section between the New York State line and the town of East Haven would range from a low of 30,000 vehicles in lightly traveled areas to a high of 78,000 in other sections.

### A 129-Mile-Long Expressway

As a final result of these studies, the Connecticut General Assembly authorized the Highway Commission to locate, plan, and construct a superhighway that would transverse the State from near the metropolitan area at the New York State line to the Rhode Island State line. Several tentative routes were considered. Finally, it was decided to start the superhighway at Greenwich, follow the coastal areas in an easterly direction to Flanders Village, near New London, then turn northeast to the Rhode Island line near Killingly, about 25 miles from Providence.

The route of the Greenwich-Killingly Expressway is approximately 129 miles long. It goes through 28 cities and towns, including such metropolitan areas as Bridgeport, Stamford, and New Haven, and many fashionable residential and resort areas. From the New York State line, the Expressway will be a 6-lane divided highway to New Haven with the exception of two 8-lane sections in Bridgeport and Norwalk. East of New Haven, the new roadway will be 4-lane divided except for two zones where traffic studies indicate two lanes are adequate. Of course, provisions have been made in the design of the Expressway to expand these sections to four lanes when increased traffic conditions warrant such changes.

The surveys included studies to determine the best possible route and, when possible, to utilize some existing road locations. The Expressway will be on new locations from Greenwich to New Haven with the exception of the recently completed Darien Expressway which will be incorporated into the new route. In the main, this

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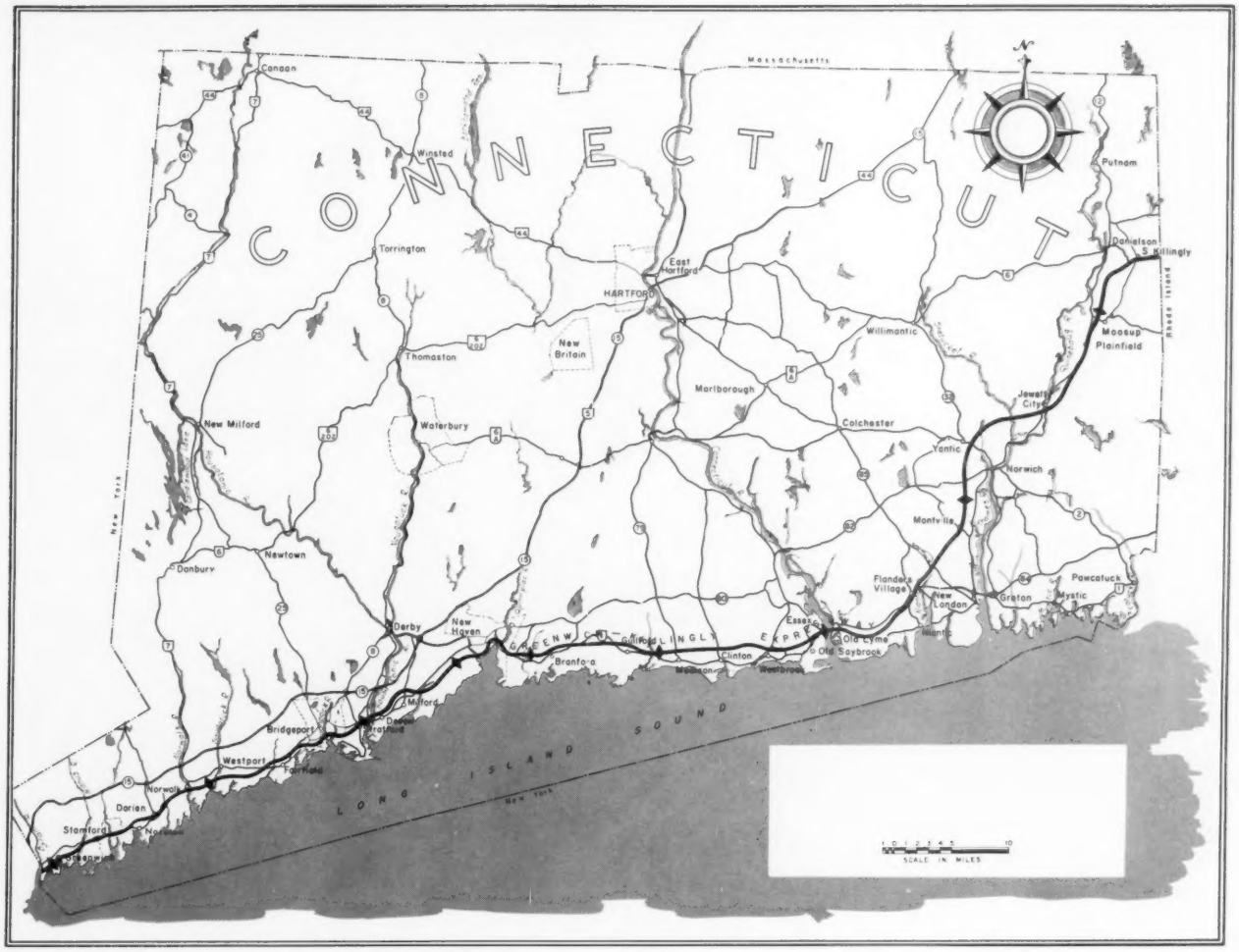


lower section of the Expressway will run through the many delightful coastal towns for which Connecticut is noted. East of New Haven, the Expressway will follow the harbor front improvement now under construction and will continue along Route U.S. 1. From that point, it will be on a new location as far as Old Saybrook where it will be joined with the Blue Star Highway, U.S. 1, to Flanders Village. From there it will extend northeasterly on a new location to the Rhode Island State line.

The Greenwich-Killingly Expressway is unique in that when the Connecticut Legislature authorized the project it did not appoint a special commission to direct the construction procedures, as many other states did under similar circumstances. The responsibility for the location, design, construction, and administration of the project was placed with the State Highway Department which must also maintain the roadway and collect tolls. Patrol work will be done by the State Police. Costs for the construction of the Expressway, toll booths, and service facilities, plus the financing, have been estimated at $445,000,000. Approximately 55 per cent of the total cost will be chargeable to the section between Greenwich and New Haven. This estimate was made because the new Expressway passes through many built-up residential and business areas in that section.

The cost of the Expressway will be financed by bonds payable from Expressway revenues. Any deficit will be made up from gasoline and special fuel taxes. The design of the Expressway follows the established standards of safe highway practice and the special requirements of arterial highways.

Normally, the right-of-way will be 300 ft. wide; however, at some locations the width will be limited to 180 ft. and at other locations it will be expanded to 450 ft. Specifications for construction of the Expressway call for each traffic lane to be 12 ft. wide, with paved outside shoulders 10 ft. wide. Curves must not exceed 3 degrees except in the New Haven area where the maximum is 5 degrees. Grades must be kept to 4 per cent or less on the Expressway itself but may go as high as 7 per cent on the ramps. Because of the anticipated greater traffic on the western half of the Expressway, plans call for a heavy-duty pavement of 9 to 10-in. layer of reinforced concrete. East of the Branford interchange where extremely heavy traffic is not expected, the road will be surfaced with 1¼-in. hot asphalt on a 2-in. binder. Where existing roads are used

CONTROLLED BLASTING: Blasting with explosives near dwellings, schools, and other structures was carefully planned and executed. The use of short-period delay caps helped to minimize vibration complaints.

DRILLING BLAST HOLES: Contractor's crews encountered variable rock formations ranging from soft mica schist to hard granite. At this location, a jib-mounted, portable Ingersoll-Rand drill is at work putting down 2¼-in.-diameter holes on 6 by 6-ft. spacings in fairly hard rock.

or where they will be expanded into four-lane highways, the new construction will conform to the original roadway specifications.

### Bridges and Viaducts

Aside from the actual construction of the Expressway, another large program involves the erection of necessary bridges and viaducts. In all, 283 such structures are needed. To carry the Expressway over highways, railroads, streets, rivers, and streams, 198 bridges and viaducts are required. An additional 76 structures are necessary to carry other facilities over the Expressway. Crossing over navigable rivers calls for 9 high-level bridges. Many of the bridges are over 2,000 ft. long – Mianus Bridge, 2,660 ft.; Housatonic River Bridge, 34 spans, 3,195 ft. long; Quinnipiac River Bridge, 26 spans, 3,773 ft. long. Other navigable rivers that will be bridged are the Byram, Norwalk, Saugatuck, Pequonnock, and Yellow Mill. The Raymond E. Baldwin bridge crossing the Con-

necticut River, recently completed as a Route U.S. 1 improvement, will be integrated with the new Expressway system.

As is the case with the Merritt Parkway, some users of the Greenwich-Killingly Expressway will not have to pay toll. Along its 129-mile length, in addition to eight toll stations, there are more than 100 entrances and exits. These provide convenient interchanges with main cross streets and roadways. The toll stations will be located at Greenwich, the Norwalk-Westport town line, at Stratford, West Haven, Branford, Madison, Montville, and Plainfield.

The comfort of travelers and the needs of their automobiles have been amply provided for with restaurants, snack bars, and service facilities at eight locations along the route.

### Landscaping

Connecticut set a high standard of

**TRANSPORTING EXPLOSIVES: Specially constructed magazines for the storage of explosives were mounted on auto trucks for the delivery of dynamite and detonators to areas where blasts had to be made along the right-of-way.**

**LOADING A BLAST HOLE: At this location, the blasting foreman and helper are loading King-Size cartridges of Gelamite 1 into 3-in.-diameter blast holes. The loading factor averaged 0.75 lb. of Gelamite 1 to a cu. yd. of rock in place.**

AFTER A BLAST: Excellent fragmentation of stratified rock formations close to homes and buildings was realized by skilled workmen directing the details of drilling and blasting.

ECONOMICAL EXCAVATION: Most of the blasting along the Expressway route had to be custom-designed to meet a wide variety of conditions. A 3½-cu. yd. P & H shovel found easy digging in this bank of blasted rock in a cut.

roadway beauty in landscaping the Merritt and Wilbur Cross Parkway systems between the New York State line and Hartford. Plans for landscaping the Greenwich-Killingly Expressway have been made from an aesthetic and functional standpoint. It will match the beauty of the Parkways in every way. Where the Expressway passes through or close to urban areas, the plantings are designed to blend into the existing landscape and reduce traffic noises. Interchanges will be landscaped to enhance safety as well as the appearance of the surroundings. The median strip will be seeded and shrubs grown to prevent headlight glare from opposing traffic lanes.

Studies of other thruways indicate there is no need for general lighting along their entire lengths. There will, of course, be adequate lighting at toll stations, interchanges, truck-weighing stations, concession areas, and on the longer bridges and viaducts.

### Geology

The geology of the Expressway route, as indicated by outcroppings and test borings, is of glacial origin with both stratified and unstratified layers. Material encountered by contractors' drill crews ranges from gravel, silt, clay, sand, and pebbles, to hardpan and boulders. Irregular rock seams present quite a problem to drillers and blasters. Swamps along the right-of-way also complicate the work of the contractors. These are of three types: upland swamps, usually a few acres in area and 5 ft. deep; lowland swamps, 20 ft. or more in depth; and tidal marshes at the river estuaries, 30 ft. deep. In addition to test borings, seismic exploration methods were utilized to determine the type and depth of rock formations. To complete construction of the Expressway, 9,267,000 cu. yd. of rock and more than 16,000,000 cu. yd. of earth will have to be excavated.

Where the Expressway approaches the shore, the terrain is low and marshy. To minimize the drainage problem, a high expressway profile is necessary. To achieve this profile an estimated 38,000,000 cu. yd. of fill material will be needed. Approximately 21,000,000 cu. yd. will be obtained from the cut sections on the

Expressway right-of-way. Along the coastal sections where local earth or rock fill is scarce, additional fill requirements will be dredged from the bed of Long Island Sound and stockpiled until needed.

The work being done by two contractors is of particular interest because it involves problems in blasting with explosives in built-up, congested areas. One of these contractors, Savin Construction Corporation of East Hartford, Connecticut, a subsidiary of Merritt, Chapman & Scott Corporation of New York City, is working between Darien and Westport. The other contractor, L. G. DeFelice & Son, Inc., of North Haven, Connecticut, is busy on the new Expressway between Westport and Fairfield to west of Mill Hill Road. The right-of-way at the above locations goes through towns, residential and suburban areas, crosses several rivers, and, for some distance, parallels the main line of the New York, New Haven, and Hartford Railroad.

**PARALLELING A RAILROAD: In the vicinity of Compo Road near Westport, the Expressway parallels the main line of the New York, New Haven, and Hartford Railroad. The fill for the roadbed of this section was dredged from the bottom of Long Island Sound.**

### The Savin Contract

Work on the Savin contract started on January 22, 1956. The 7 miles of Expressway involved the removal of about 1½ million cu. yd. of excavation, including approximately 700,000 cu. yd. of rock. The right-of-way goes through everything from hard rock to swamp land. However, the predominant material that called for blasting with explosives was a granite type of mica schist. Although full of seams, it was not difficult to break. The remainder of the material was easily taken care of by mechanical earth-moving equipment.

Also involved were two deep cuts: Strawberry Hill, with 420,000 cu. yd. of excavation; and Keeler Brook, with 775,000 cu. yd. The cuts averaged 30 ft. deep, with one 50 ft. deep.

### Drilling

Drilling on the Savin contract was adequately handled by two Joy T 500 Challenger drills with 4-in. bits; two Ingersoll-Rand Drillmasters producing 6 and 6½-in. holes; two Gardner-Denver Air Tracs for making 3-in. holes; and seven Ingersoll-Rand wagon drills for 2¼-in. holes. Compressed air to keep these drills working was supplied by two Ingersoll-Rand rotary air compressors, one of 600-c.f.m. and the other of 900-c.f.m. capacity.

In utilizing this wide range of equipment, special blast-hole drilling patterns were devised, depending on the condition of the rock, the depth of cut, and the congestion in the blast areas. On the average, the spacing was on 8-ft. centers for the smaller diameter holes. The Joy Challenger holes were drilled on 9-ft. centers, while the Ingersoll-Rand Drillmaster hole spacing was 12 by 14 ft. The depth of the holes varied from 20 to 35 ft., depending on the depth of the cut.

### Blasting

The holes were loaded with Gela-

AFTER A BLAST: Excellent fragmentation of stratified rock formations close to homes and buildings was realized by skilled workmen directing the details of drilling and blasting.

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**PARALLELING A RAILROAD: In the vicinity of Compo Road near Westport, the Expressway parallels the main line of the New York, New Haven, and Hartford Railroad. The fill for the roadbed of this section was dredged from the bottom of Long Island Sound.**

### The Savin Contract

Work on the Savin contract started on January 22, 1956. The 7 miles of Expressway involved the removal of about 1½ million cu. yd. of excavation, including approximately 700,000 cu. yd. of rock. The right-of-way goes through everything from hard rock to swamp land. However, the predominant material that called for blasting with explosives was a granite type of mica schist. Although full of seams, it was not difficult to break. The remainder of the material was easily taken care of by mechanical earth-moving equipment.

Also involved were two deep cuts: Strawberry Hill, with 420,000 cu. yd. of excavation; and Keeler Brook, with 775,000 cu. yd. The cuts averaged 30 ft. deep, with one 50 ft. deep.

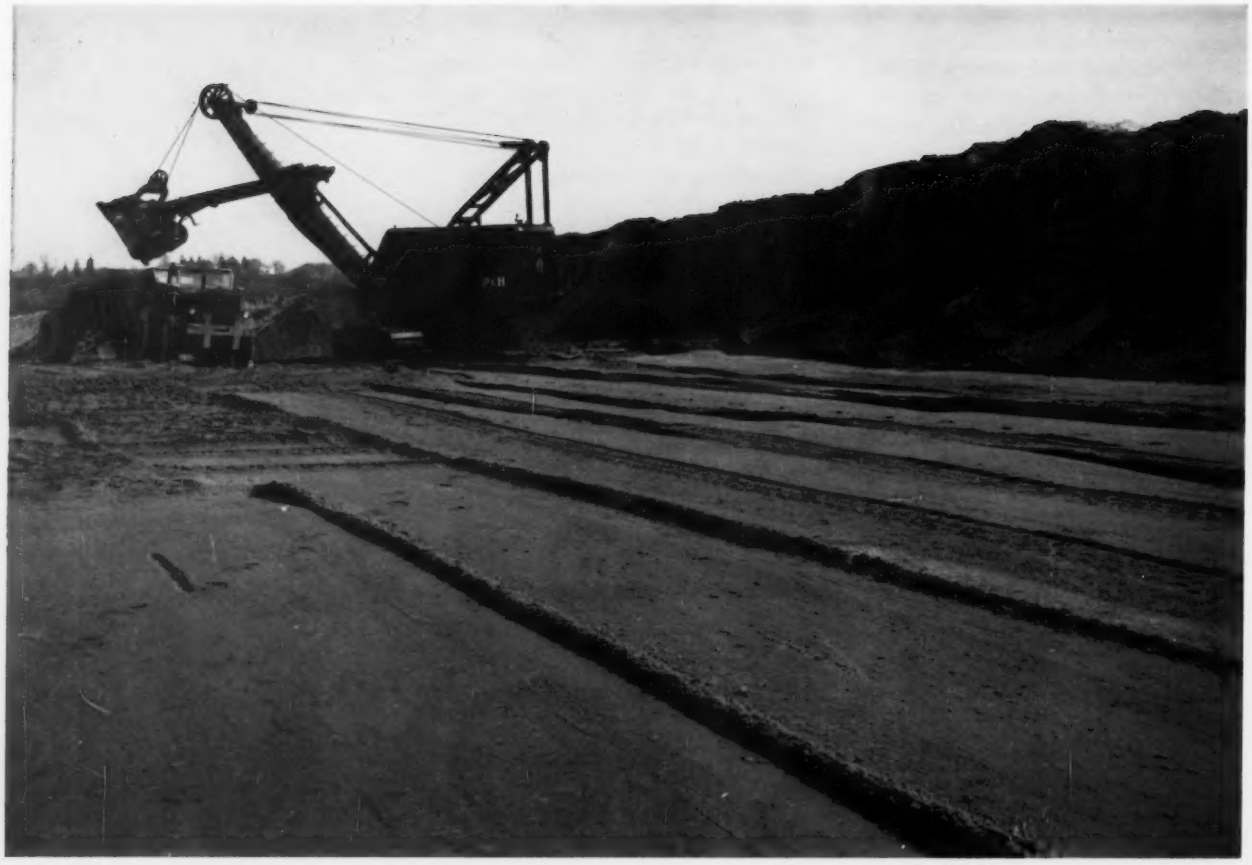
### Drilling

Drilling on the Savin contract was adequately handled by two Joy T 500 Challenger drills with 4-in. bits; two Ingersoll-Rand Drillmasters producing 6 and 6½-in. holes; two Gardner-Denver Air Tracs for making 3-in. holes; and seven Ingersoll-Rand wagon drills for 2¼-in. holes. Compressed air to keep these drills working was supplied by two Ingersoll-Rand rotary air compressors, one of 600-c.f.m. and the other of 900-c.f.m. capacity.

In utilizing this wide range of equipment, special blast-hole drilling patterns were devised, depending on the condition of the rock, the depth of cut, and the congestion in the blast areas. On the average, the spacing was on 8-ft. centers for the smaller diameter holes. The Joy Challenger holes were drilled on 9-ft. centers, while the Ingersoll-Rand Drillmaster hole spacing was 12 by 14 ft. The depth of the holes varied from 20 to 35 ft., depending on the depth of the cut.

### Blasting

The holes were loaded with Gela-



**FILL STOCKPILE: Dredges were used to remove fine gray sand from the bed of Long Island Sound for use as fill material. Approximately 2,000,000 cu. yd. of this sand were stockpiled on flatlands where it drained until needed as fill in several sections of the right-of-way.**

mite® 1 in a variety of cartridge sizes — 1½ by 8 in., 2 by 16 in., 3 by 16 in., 5 in. by 25 lb., and 4½ in. by 20 lb. The loading factor was 0.75 lb. of Gelamite 1 to 1 cu. yd. of rock in place.

The dynamite charges in the larger diameter holes were primed with Primacord* and Hercules® Short-Period Delay Electric Blasting Caps, with delay periods 1 to 10. The leg wires of the caps were taped to the Primacord at each hole. The smaller diameter holes were primed in the conventional manner, with a short-period delay cap as the primer in each hole. All of the loaded holes were connected in series and fired by a Titan® blaster, a condenser type of firing device. Holes were stemmed the entire length with sand, which was brought in by truck. This contributed to good rock breakage and helped to minimize hazards to surrounding structures.

No standard number of holes were fired at one time. This was dependent upon the number of holes drilled each day. An average primary blast consisted of 100 to 150 holes 14 ft. deep, spaced on 6 by 6-ft. centers. Such a blast would normally require 1,000 lb. to 1,500 lb. of Gelamite 1. Occasionally larger blasts consisting of 5,000 lb. of Gelamite 1 would be made. Because of the congested areas on most of the right-of-way, the blasts were kept small to avoid damaging nearby structures. The explosives-loading ratio of 0.75 lb. of Gelamite 1 per cu. yd. of material produced excellent breakage. A minimum of secondary blasting was necessary.

Because of the extreme care exercised and the use of short-period delay caps in all blasting operations, there was a minimum of vibration complaints.

### Equipment

The Savin organization had three shovels working on its two contracts: two 3-cu. yd. units, a Marion 101-M and a Bucyrus-Erie 71 B; and a 3½-cu. yd. P & H 1055. They proved adequate in keeping a fleet of 15 diesel-powered Euclid 16-cu. yd. trucks and four LeTourneau-Westinghouse diesel-electric 20-cu. yd. Model B haulers busy transporting excavated material to fill locations on the right-of-way. A 1¼-cu. yd. Bay City dragshovel was used in digging culvert ditches. Six Caterpillar D-8 and D-9 bulldozers were also used on the roadway.

Working one 10-hour shift a day six days a week, engineers for Savin estimate that at the present rate of progress the excavation and grading will be completed by July, 1957, and the right-of-way ready for paving operations. The Savin contract includes 12 bridges.

Savin Construction Corporation's field office is located at Norwalk, Connecticut. This is headquarters for L. F. McCarthy, project manager; C. Bro-

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

velli, project superintendent; W. J. Burns, assistant project superintendent; R. C. Chapman, project engineer; and E. E. Hazard, office manager. The blasting foremen are Alva Housenfluk and George Sabolcik.

### The DeFelice Contract

L. G. DeFelice & Son, Inc., of North Haven was awarded the contract for projects 308-01 and 308-02 calling for grading, draining, and paving the section between Westport, east of Compo Road, to Fairfield, to west of Mill Hill Road. Included in these projects are 13 bridges.

Rock cuts on the DeFelice contract averaged 28 ft. deep. In some areas, where the right-of-way was relocated, cuts reached a depth of 40 ft. The material encountered ranged from hard granite to soft mica. Approximately 205,000 cu. yd. of rock and 200,000 cu. yd. of conglomerate material were excavated.

Holes for blasting in the cut sections were drilled by four jib-rigged Ingersoll-Rand Model J 260FMC units, mounted on the rear of D-8 Caterpillar tractors. Four Ingersoll-Rand Model FM2 wagon drills and two Joy T 500 Challenger drills were also used. The wagon drills made 2¼-in.-diameter holes while the Challengers sunk holes 4 in. in diameter. Compressed air was supplied by an Ingersoll-Rand 600 rotary compressor.

### Drilling and Blasting

Blasting posed problems because of nearby structures, highways, and the New York, New Haven, and Hartford Railroad. Because of these conditions, no definite drilling and explosives-loading pattern was adhered to. Blasting was done when a sufficient number of drill holes was available for loading the explosives and to keep shovel operators busy.

When the Joy Challengers were used, the drilling pattern averaged 9 by 9-ft. spacings. The depths of holes ranged from 25 to 40 ft., depending upon the cut. The Ingersoll-Rand jib units drilled on 6 by 6-ft. spacings, with holes 9 to 18 ft. deep. Using a powder factor of 0.87 lb. of Gelamite 1 per cu. yd., Ned Maranellie, the blasting foreman for DeFelice, had no difficulty in getting good breakage.

**NEARING COMPLETION: Excavating and grading on this part of the Expressway near Westport are nearing completion. Surface-paving crews will soon move in to transform the section into an ultra-modern, six-lane divided superhighway. Landscaping will beautify the slopes and median strip along the right-of-way.**

When the blast area was extremely wet, Hercules® 60% Gelatin Extra was used. The Gelamite 1 was packed in 1½ by 16-in. and 3 by 16-in. cartridges, the Gelatin Extra in 1½ by 16-in. cartridges.

Sand for stemming was trucked in and all loaded holes were filled to the collars. Each hole was primed with a Hercules Short-Period Electric Blasting Cap, using 1 to 10 periods of delay. The cap leg wires were connected in series and blasts were fired by a Titan blaster. Fragmentation was exceptionally good and very little secondary blasting was required.

The local fire marshal was notified before a blast was fired. All traffic was stopped and other safety precautions taken to prevent injury or damage.

Three Bucyrus-Erie shovels, one 22-B and two 54-B's, were used for excavating the blasted rock. Three Northwest Model 6's and one 80-D plus a Northwest Model 25 dragline handled the earth excavation. The rock- and earth-hauling vehicles were Euclids of varying capacities.

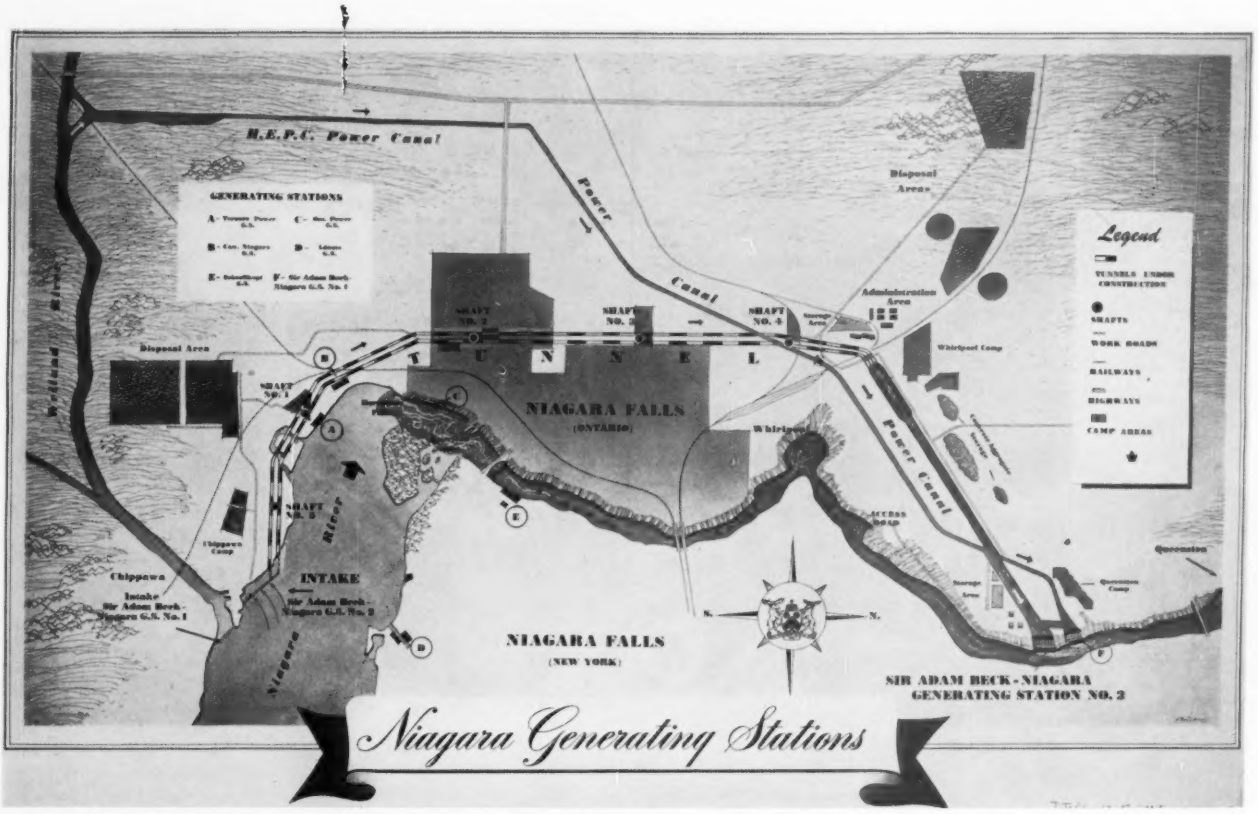
### Dredging

One unusual feature of the two sections of the Expressway under contract with the DeFelice organization was the method of obtaining fill for certain areas requiring a high profile and where there was an inadequate supply of local fill material. Dredges were emloyed to remove fine gray sand from the bottom of Long Island Sound and stockpile it in nearby flatlands where it drained until needed for fill. About 2,000,000 cu. yd. of sand were realized from this dredging operation.

The hauling requirements on the DeFelice contract were adequately met by a fleet of 33 Euclid diesel trucks, both rear-dump and bottom-dump types. The excavated material and the fine sand from the stock pile were transported to places needing fill where the grading was done by bulldozers.

The field office of L. G. DeFelice & Son, Inc., located outside Westport, is headquarters for Joseph DeLucia, project superintendent; M. Romei, assistant superintendent; Victor Hallberg, project engineer; and Lawrence Giariari, office manager.

**HIGH-LEVEL BRIDGE: High-level bridges are being built at nine locations to enable the Expressway route to cross navigable rivers. A pontoon bridge was built alongside the main structure for use by the contractor's vehicles during construction.**




**THE OVERALL PROJECT:** In this reproduction of the overall project, the two broken lines in parallel indicate the locations of the twin tunnels, each 5½ miles long, under the Canadian city of Niagara Falls.

# DRIVING TWIN ROCK TUNNELS IN ONTARIO

## The construction of two parallel tunnels, each 5½ miles long and 51 ft. in diameter, under the city of Niagara Falls, Canada, required the blasting and excavating of 4,375,000 cu. yd. of rock

ROBERT DYMENT*

Six miles below the famous cataracts of Niagara Falls, on the Canadian side of the 300-ft. cliff of the lower Niagara River gorge, the new Sir Adam Beck-Niagara Generating Station No. 2 is nearing completion. This new project of the Hydro Electric Power Commission of Ontario is located a short distance from the Sir Adam Beck-Niagara Generating Station No. 1, which began operations in 1930.

The new No. 2 Generating Station, together with its tunnels, canals, and forebays, is the largest engineering project ever planned by the Ontario Hydro Commission and one of the important engineering feats to be accomplished in North America. Started in 1950, it is scheduled for completion during 1957. Its cost will total $343 million. More than six thousand men were employed during the peak of this gigantic construction project.

When No. 2 Generating Station is in full operation, it will have a capacity

*82 East Fifth Street
Dunkirk, New York

HAZARDOUS WORK: Riggers had to scale the 300-ft. cliff of the Niagara Gorge and gouge into the walls of rock to make beds for the penstocks of the new generating plant.

of 1,828,000 horsepower. Along with No. 1 station, the capacity of the two units will approximate 2,353,000 horsepower. This will provide the source of power for nearly all the Canadian Province of Ontario, including the city of Toronto, the second largest metropolitan area in Canada.

### Tunneling Under a City

To obtain water to operate the No. 2 station, two intake structures will receive water from the Niagara River at a point above the Falls and send it through two tunnels, each 5½ miles long. The driving of these twin tunnels required the blasting and excavating of approximately 4,375,000 cu. yd. of rock. Each tunnel has an unfinished diameter of 51 ft. This was reduced to 45 ft. when the concrete lining was applied. The tunnels run under the Canadian city of Niagara Falls and emerge at the surface on the opposite side of the city. There, the water will flow into a canal 2¼ miles long which will channel the water into the forebay of the new station.

The deepest penetration of the tunnels below ground surface was 330 ft. Before emerging at a 30-degree slope to the open canal, this penetration rose to an elevation of 207 ft. below the ground level. The tunnels were located at this depth to take advantage of a stratum of limestone averaging 10 ft. thick which provided adequate roof support. Also, tests showed there would be less gas and seepage at the above depths.

More than 43,900 tons of structural steel were used in supporting I-beam structures. Lining the tunnels required 954,800 cu. yd. of concrete. The concrete was delivered to the tunnel locations through 8-in. holes drilled vertically from the surface along the center lines of the tunnels.

### Five Shafts for Each Tunnel

To speed construction, the two tunnels were driven parallel to each other from five shafts sunk into each tunnel. The shafts were located at the centers of 250-ft. crosscuts between center lines, making a total of 20 headings that were driven at the same time.

A contract for the construction of two of the five sections of tunnel was awarded to Rayner-Atlas Company, a

**DRILLING INTO THE BENCH: The contractors used the heading and bench method of drilling and blasting in the tunnels. Specially designed jumbos were employed. This view shows a crew drilling vertical holes into a bench, with the jumbo spanning the bench.**

Canadian firm, while the contract for the remaining three was awarded to a firm from the United States, Perini-Walsh and Associates, a joint venture of Perini Corporation of Framingham, Massachusetts, and Walsh Construction Company of New York City. The construction of the intake canal and the power station is being done by Hydro Electric Power Commission of Ontario forces.

To meet the heavy ventilation requirements of rapid tunnel advance, the shafts, included two vent pipes, 4 ft. 6 in. in diameter, connected to two fans rated at 75,000 c.f.m., each powered by a 300-hp. motor. The fans are reversible and were used for blowing fresh air into the headings, and to withdraw the air for short periods after blasting.

Compressed air was delivered to the headings through 6-in. lines suspended from steel sets. The operation of the drills accounted for slightly more than half of the compressor capacity, the remainder being used for many purposes, including the operation of loading gates at skip pockets.

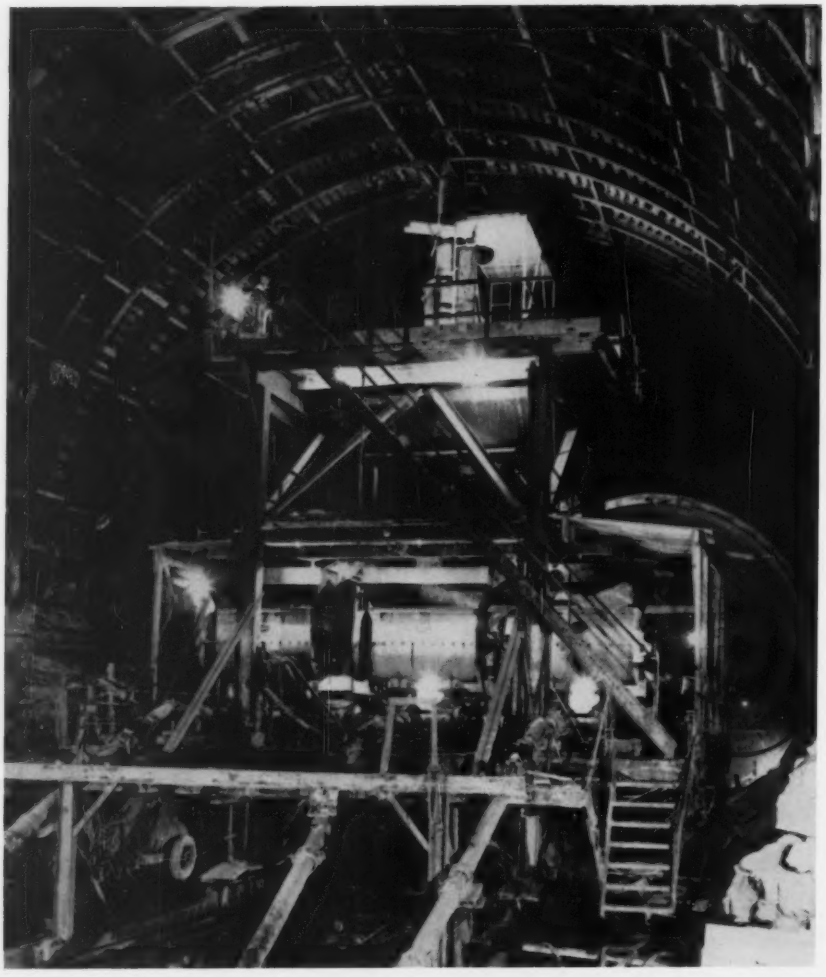
### Blasting and Excavating

For a top-heading face, a typical drill round consisted of 159 holes varying in length from 11 ft. to 24 ft. for the cut holes in the center and 20 ft. for the outside holes. The types and strengths of explosives used varied from section to section. In general, 70% semigelatin, in 1⅛ by 8-in. cartridges, was loaded into the cut holes and 40% gelatin extra in the other holes. The explosives-loading factor was 0.52 lb. per ft. of hole drilled.

The loaded charges were primed with delay electric blasting caps in delay periods from 0 to 15. The cap leg wires were hooked onto a bus wire which, after loading was completed, was connected to a special blasting circuit. The lifter holes were usually double primed. At Shafts 1 and 2, short-period delay electric blasting caps from 0 to 18 were used.

Before the explosives-loading operations began, all power was shut off from the jumbo. This was done as a safety measure to prevent premature detonation through currents straying along the steel work of the structure. Also, a close watch was kept on weather forecasts at frequent intervals throughout the day. No loading of explosives charges was permitted if an electrical storm appeared imminent.

After blasting, the broken rock was excavated by either diesel or electric



CONCRETE LINING: In lining the arches of the tunnels with concrete, three pumpcrete machines were used in each section. Shown here is one of the units pumping concrete upward into the arch form.

COMPLETED TUNNEL SECTION: The immense spiralling whorls of concrete that line this section of one of the tunnels dwarf the workman. Lining the twin tunnels required 954,800 cu. yd. of concrete. The diameter of each lined tunnel is 45 ft.

shovels. The shovels, with shortened booms and dipper sticks for working in close quarters, were equipped with 3½-cu. yd. buckets. A bulldozer and tractor-mounted overhead loader were used for clean-up work. The shovels loaded into 14-cu. yd. diesel trucks which dumped the blasted rock through a grizzly to a skip-loading pocket situated directly below the shaft crosscut.

### The Jumbo

Of particular interest was the method of benching the floor of a top heading to invert grade. A special jumbo, developed by Perini-Walsh and Associates, was used. Later, it was adopted and used in all sections.

Essentially, the jumbo consisted of two 18-in. I-beams, which, together with its decking and bracing, were suspended from trolley rails at either side of the tunnel. The trolley rails, in turn, were suspended from three adjacent ribs, using simple-gravity cam clips. Over each of the I-beams, which were 10 ft. apart, a long quarry bar was fixed, on which the machines were set in a vertical position, there being one machine for each hole in a row. Two rows of holes could be drilled at a time from this jumbo. On this project, only one row was used. On completion of a row, the jumbo was quickly advanced to the next row.

In drilling a round of bench holes, one contractor "toed" the holes at an angle of 85 degrees from the vertical, except for the final row. This was drilled with vertical holes at an initial burden of 1 ft. to give a clean, smooth bench. Bench excavation accounted for 29 cu. yd. of rock per foot of advance.

In blasting benches, short-period delay electric blasting caps were used throughout. The same safety regulations enforced in blasting the top headings were also observed here.

### Blasting at Canal Site

After clearing the overburden at the canal site, ranging from 20 to 30 ft. thick, the rock was excavated in two lifts. This began on the downstream side of the crossover, drilling with 4-in. wagon drills, using 2-in. detachable bits as starters, decreasing to 1¾-in. gauge at the bottom of the 20 to 25-ft.

holes. In this work, the drill pattern was 5 by 6 ft., and the holes were loaded with 40% gelatin in 1⅛ by 8-in. cartridges. The charges were primed with short-period delay caps, using periods of delay 0 to 11. A berm was left along either wall for later excavation by close-spaced holes in order to provide a smooth rock wall. Specifications did not call for concrete lining, except in the trapezoidal section and in portions of the crossover.

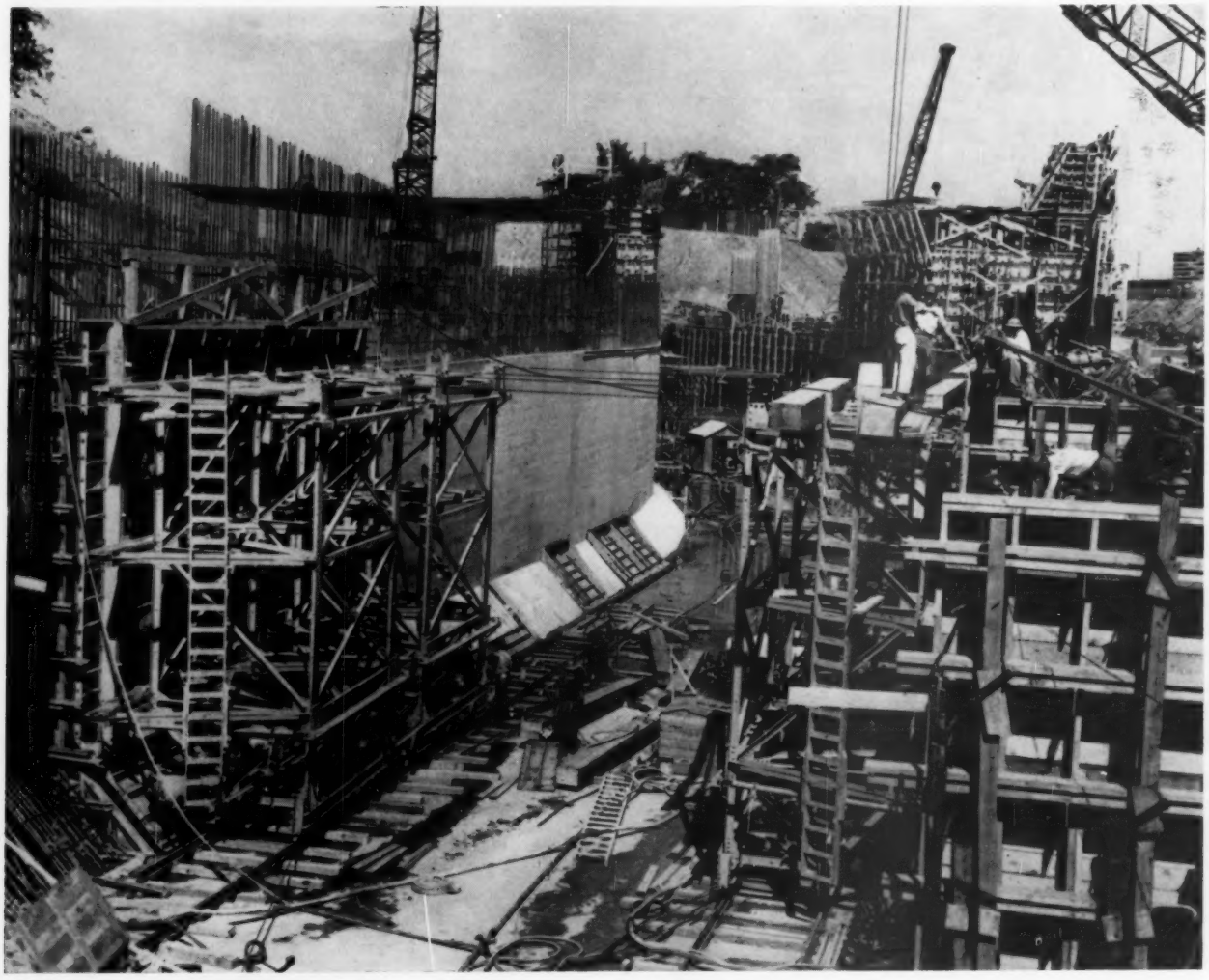
All of the upper lift upstream from the crossover, and the entire lower lift, were drilled with large drills, three of which were percussion machines equipped with tungsten carbide bits, and two rotary drills using chilled steel bits. These drills produced holes 6¼ in. and 6¾ in. in diameter, respectively. In the lower lift, the depths of holes ranged between 30 and 45 ft., depending upon the elevation of the parting plane between the Gasport Limestone and the De Cew dolomite below the drilling horizon.

With the big drills, the drilling patterns varied from 12 by 12 ft. on 30-ft. benches to 15 by 15 ft. on higher benches. The holes were loaded with 5 by 16-in. cartridges of 60% and 70% dynamite. Rounds of 400 holes were fired at a time, using short-period delay electric blasting caps with delay periods from 0 to 11, in a modified "herringbone" sequence. As a result, holes in the center of the canal tended to throw their burdens in a direction parallel to the canal, and holes at the side transversely. The explosives factor in this work was approximately 0.85 lb. per cu. yd.

As walls were approached, drilling patterns were modified and explosives charges reduced.

### Wall Trimming

The following practice of wall trimming was developed through a considerable amount of experience on this job. Along the walls, the 6¼-in. and 6¾-in. holes were spaced at 5-ft. intervals and a 5 by 6-ft. pattern developed for a short distance from the wall toward the center of the canal. Three wagon drill holes were drilled in the 5-ft. interval between the main holes



**WORKING BELOW RIVER LEVEL:** The work of constructing this gathering tube was carried on at a location 66 ft. below the level of the Niagara River. The cofferdam at right held back the river water.

**OPEN-CUT CANAL: This open-cut canal, 70 ft. deep and 200 ft. wide, links the tunnels to the headworks. The canal will handle 40,000 cu. ft. of water a second, the discharge from the two tunnels.**

**THE GENERATING STATIONS: In this view of the Sir Adam Beck-Niagara hydroelectric project in Ontario, the original No 1 Generating Station is in the foreground at right and the new No. 2 Generating Station is at left.**

along the trim line. Of these small holes, only the center one was loaded, to about 4 ft. from its collar. In addition, the main holes were "cushion-blasted." This procedure consisted of hanging a string of explosives down the side of the hole remote from the wall and filling the space with rock screening. The explosive string was made by attaching 1⅛ by 8-in. cartridges of dynamite to a length of detonating fuse. In this trim work, the explosives factor averaged about 0.5 lb. per cu. yd.

At the height of this big construction job, canal excavation was carried on at several sections simultaneously. Seven shovels and a fleet of 90 diesel dump trucks were employed.

The author extends grateful acknowledgment and appreciation for help in preparing this article to the editor of *Canadian Mining Journal* and the Hydro Electric Power Commission of Ontario, Canada.

# CROSSING THE SUSQUEHANNA WITH A PIPELINE

## A summary of Western Construction Company's unique equipment and operating methods as presented in the April issue of The Oil and Gas Journal

PAUL REED*

A NEW unit for pipelining at inland river crossings looks as though it might have been designed under the influence of ideas for offshore well-drilling platforms.

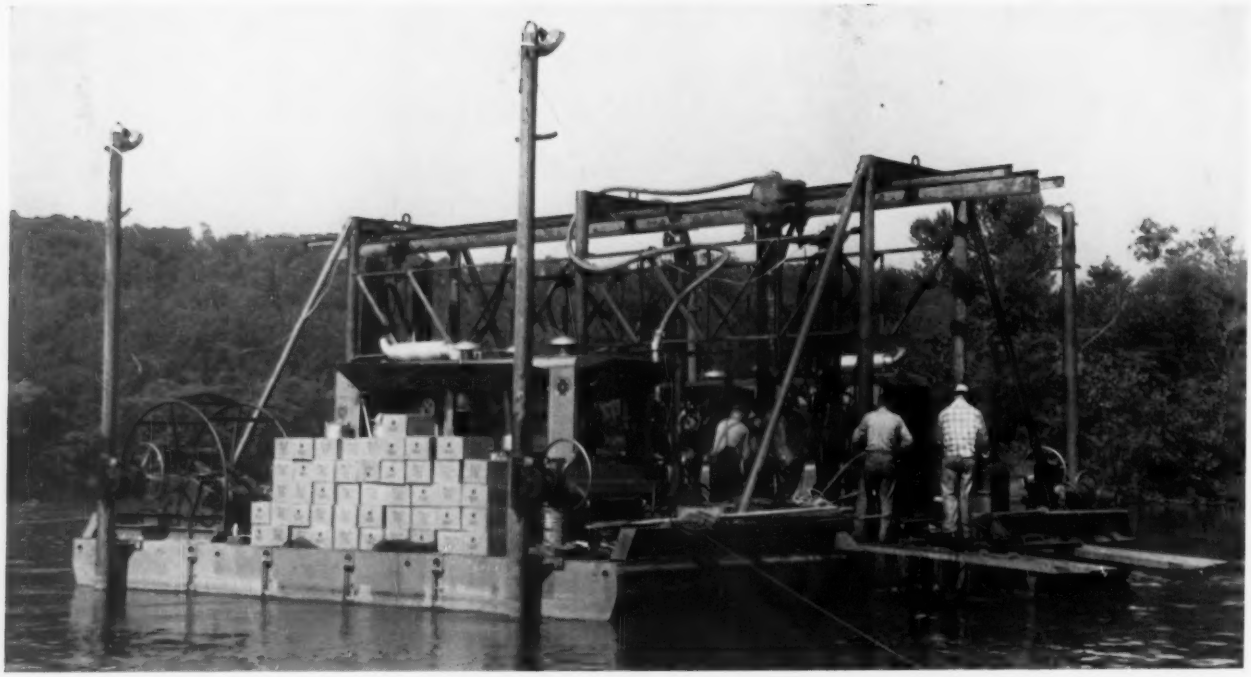
*Pipeline Editor
The Oil and Gas Journal
Tulsa, Oklahoma

To expedite the drilling of shot holes in rocky river beds, an entirely different type of unit has been developed by J. P. Neill & Co. and C. S. Le Noir & Co. Neill and Le Noir operate as a joint venture known as Western Construction Co., pipeline contractors.

Since it was built for laying a 30-in. crossing for Transcontinental Gas Pipe Line Corp. in 1956 at the Susquehanna River in Pennsylvania, it is called the "Susquedriller."

This is the first application of pneumatic rock drills to shot-hole drilling

**THE CROSSING LOCATION: At the pipeline-crossing location, the Susquehanna River is 4,700 ft. wide. This is due to the fact that the point of crossing is between two dams, one above it and one below.**



**THE SUSQUEDRILLER: This uniquely designed drill barge was used for first time on the Susquehanna River-crossing job. It represents one of the outstanding innovations in recent years for pipeline construction.**

from floating equipment for a pipeline river crossing. Previously wagon drills had been used at small stream crossings.

It represents the most important advance for the technique of laying pipe across a rocky river. And it is one of the outstanding innovations in recent years for pipeline construction. It has proved its value in faster construction and lower costs. The new methods developed promise to influence future pipelining across rocky rivers.

### Susquedriller Basic Features

Essentially the Susquedriller is a floating A-frame mounted between barges from which two sets of twin pneumatic drills are suspended. Compressors and other equipment are carried on the barges on each side. The drilling equipment moves the entire 40-ft. length of the overhead I-beam.

Drilling time is estimated to be a third to a quarter of that taken by the usual cable-tool spudder method. And the trench can be dug to follow the engineers' survey more accurately.

### Offshore-type Drilling

Like a seagoing portable well-drilling platform, the Susquedriller has provision for raising its own platform on the spuds. But this upward movement is usually only just enough to equalize the weight of the two barges so that the spuds have a firmer bearing in the river bed.

The Susquedriller was designed particularly for operating in a swift river. Still the basic problem resembles that of the offshore drillers.

### Problem of Rigidity

Before laying Transco's Susquehanna River crossing, Charles S. Le Noir decided to make shot holes with pneumatic rock drills if he could devise a means for holding the barges securely during drilling operations. He saw that such a drilling method would be much faster than the usual one of drilling shot holes with cable-tool spudders mounted on barges.

The problem of attaining rigidity was solved by an original design of C. S. Le Noir in collaboration with B. W. Williams and E. J. Price.

Secure positioning of the barges is obtained by means of winches at each of the four spuds. These winches throw weight on the spuds to hold them rigidly. Weights are equalized. And the slight raising of the barge also reduces the effect of the current on the barges.

### Susquedriller in Brief

Here are the main features of the Susquedriller unit:

Two twin deep-hole pneumatic drill units (each mounted on H-frames) drill the shot holes.

These are suspended from a 40-ft. I-beam which serves as a track on which they are moved from one drilling position to another.

This track is supported by an A-frame superstructure mounted on two barges, spaced 6 ft. apart to provide an opening for drilling between the barges.

Each of the two barges, 30 ft. long and 8 ft. wide, was formed by latching together two smaller barges.

To insure that the barges are held in a rigid position, a spud is placed at each of the four corners of the main floating two-barge assembly.

Throwing of the weight on the spuds is accomplished by a hand-operated winch at each spud.

From one location to another, the barge is jockeyed by anchor lines manipulated by air-powered winches. Only 30 minutes is taken in moving to the next location and starting again.

On each barge there is a 900-cu. ft. per minute air compressor serving one of the two twin drills. The barges also carry dynamite, Primacord,* drill

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

steels, tamping steels, and diesel fuel. These together with the weight of the superstructure supporting the drills, weight of twin drill units, and the weight of the barges on both sides of the drilling space amount to a total of 90,000 lb.

The barges draw 2 ft. of water when unsupported by the spuds.

### Delta Crossing

The Susquehanna River crossing is on a Transco loop in the Delta, Pa., area at a point extending from Quarryville, Pa., to Forest Hills, Ind. The unusual width of 4,700 ft. for a rock crossing is due to the fact that it is in an inundated valley between two dams. The crossing is 1½ miles from the Holtwood Dam downstream and 10 miles from the big Conowingo power dam upstream. Average depth of water at the crossing is 14 ft. Water level varied as much as 5 ft., depending on the amount released from the Conowingo Dam. The river has a quartz seam which makes the bottom rough.

From hour to hour close contact was maintained with the power dam so as to anticipate changes in water levels.

### Dam Break

On one occasion, when the upstream dam broke, water rose 11 ft. in 30 minutes. The Susquedriller was flooded, some ditch was washed out, and a 2,600-ft. section of pipe was taken 200 ft. downstream. In flood periods the current reached 8 m.p.h.

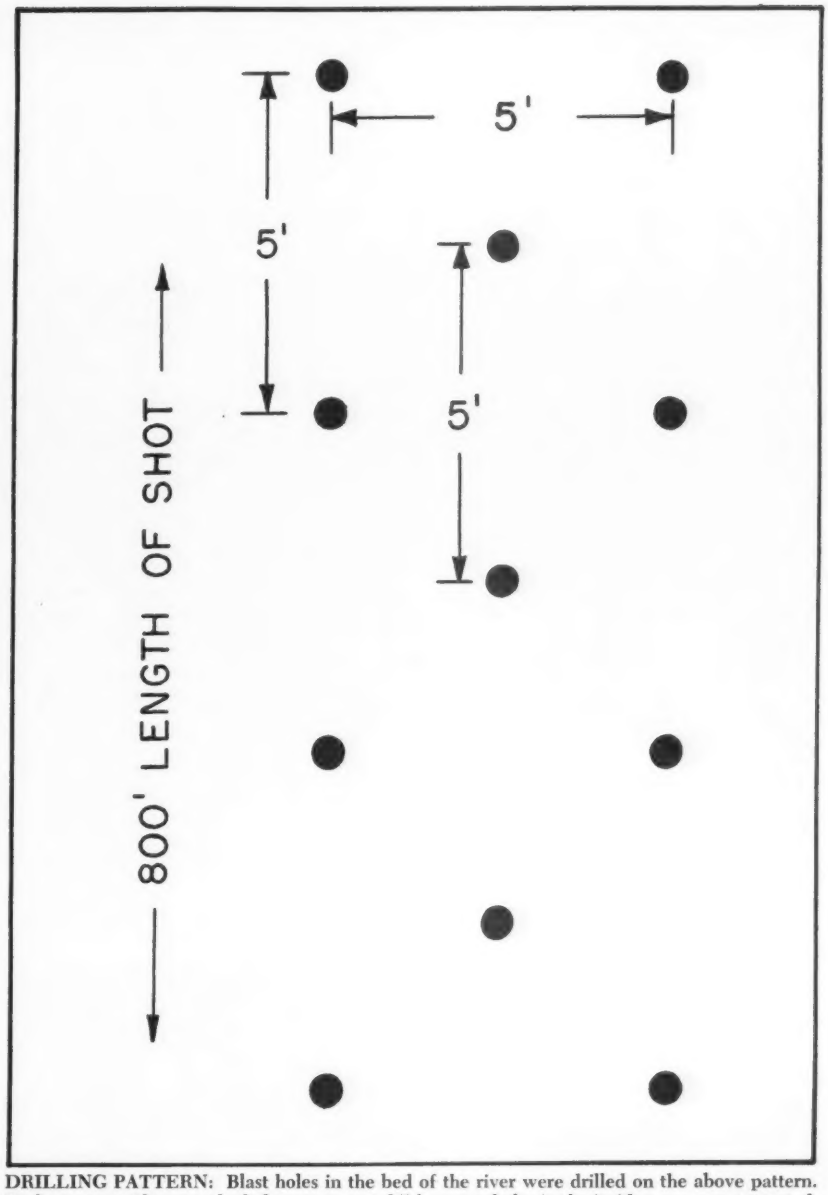
The trench was 8 ft. deep and 5 to 10 ft. wide for holding the 30-in. pipe which had an outside diameter of 36 in. due to the concrete jacketing.

The project was complicated by the job of keeping fishing boats away from operations night and day. An effort was made to stop the public from getting within 1,500 ft. of the job.

### Drilling

The 3,123 shot holes were drilled in 34 days. A five-spot pattern was used with the holes spaced 5 ft. apart in the outside rows. The inside row was staggered, using the same spacing. Average depth of hole in the rock was 10 to 11 ft.

The close spacing was preferred because it produced more fragmentation through greater shattering effect which




**DRILLING PATTERN:** Blast holes in the bed of the river were drilled on the above pattern. In the two outside rows, the holes were spaced 5 ft. apart; holes in the inside row were staggered, using the same 5-ft. spacing.

**CONNECTING THE CHARGES:** Each of the three rows of loaded holes was identified by different colored floats attached to the Primacord extending from each hole. This provided positive identification when the branch lines of Primacord were connected to the trunk line.

SUBMARINE BLASTING: The use of an explosives-loading factor of about 20 lb. of 80% gelatin per cu. yd. of rock resulted in excellent breakage and economical mucking operations.

OPERATING SUPERVISORS: Left to right, K. K. Kelly, superintendent, Western Construction Company; T. A. Ferguson, inspector, Transcontinental Gas Pipe Line Corporation; W. B. Williams, general superintendent, Western Construction Company; V. R. McGehee, inspector, Transcontinental Gas Pipe Line Corporation.

meant less work in clamming out the ditch afterward. It is cheaper in the end to spend more money on explosives for good shattering.

Holes were 5 in. in diameter for the top 12 in. They were tapered to 4 in. for the rest of the hole. The tapered hole facilitated loading with explosives.

The drills hanging from rollers on the overhead track could be revolved so as to make the center holes in the five-spot. Holes are drilled four at a time.

The drill steel was of "locked-in construction." This meant that additional lengths could be quickly coupled.

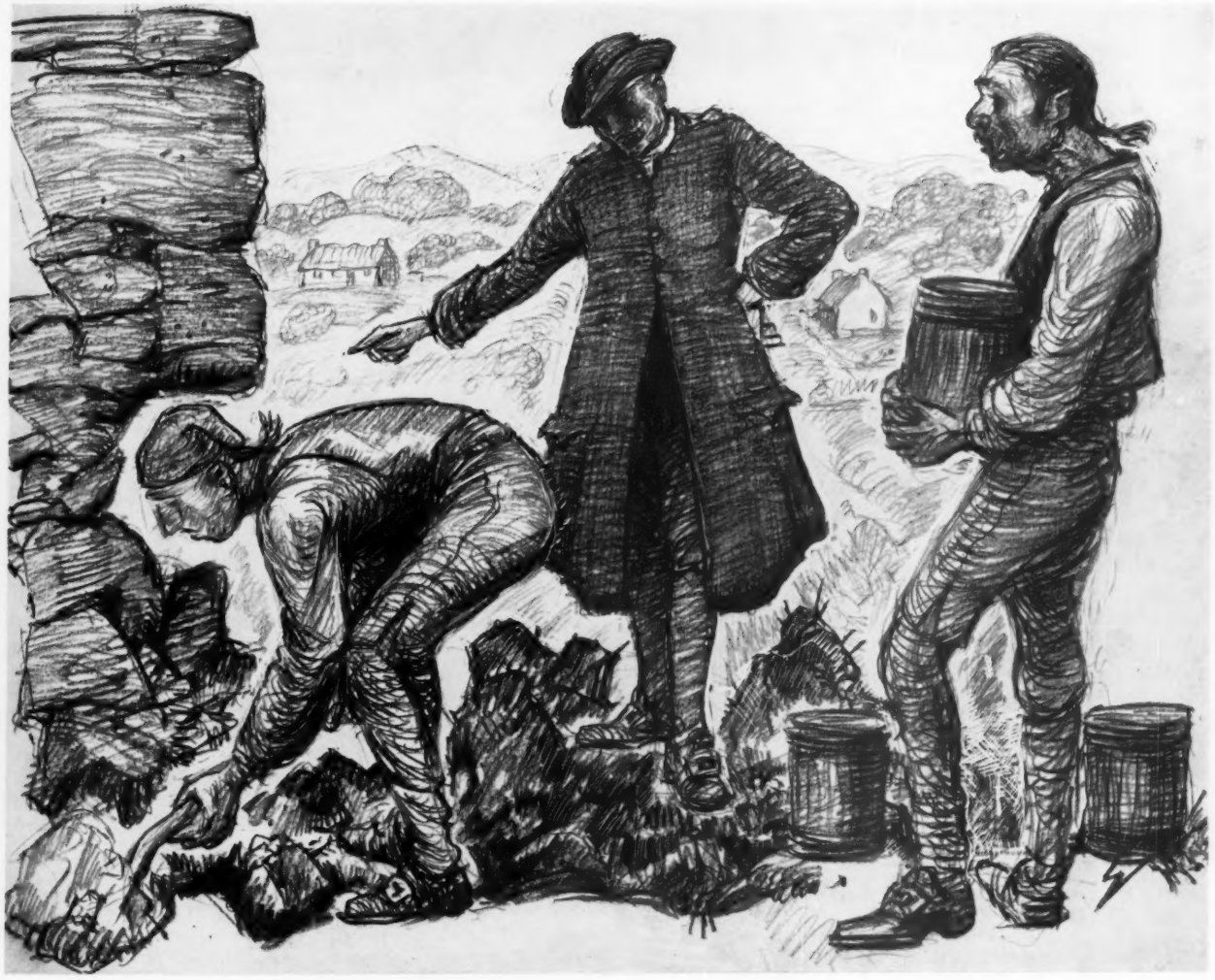
Timken carbide 4-in. detachable bits were used in making the drill holes.

In connection with drilling operations, drill steel was fed and lifted by an air motor-operated chain drive.

The hole was cleaned by compressed air injected through a blow pipe.

Drilling was completed in the 34 days shortly before the big shooting on

(Continued on page 92)



# The First Explosives Engineer

C. ROBB*

THE first explosives engineer on record was Justinian Watson, an officer of the military engineering branch of the Ordnance of the British Army.

History reveals that in 1754 Officer Justinian Watson was designated a "Practitioner Engineer" in the corps, now known as the Royal Engineers. On October 3, 1756, he was assigned to the Irish Establishment as "The Gunpowder Artifice." His principal duty on the assignment in Ireland was to use gunpowder in military demolitions. He was for certain the expert engineer who used the common explosive substance, black powder. In those days, black powder was usually referred to as gunpowder because of its early application.

In 1757, Officer Watson, in his uniform of scarlet tunic faced with black velvet, was engaged in the demolition of the Black Castle tower at Drogheda. The tower had withstood a siege by Oliver Cromwell and was in a dangerous condition. Watson supervised the loading of charges of gunpowder in holes under the two corners in the rubble walling and in tamping them in place, first with paper wads, then with blue clay. The firing of the powder charges brought the whole structure tumbling down in the roadway.

In the days of the Peninsula War, gunpowder was used by the officers and men in the British Army to blow up bridges and similar crossings against the advancing French Army. More than 100 pounds of the powder were laid on the crown of the arches of these structures; sometimes the skews of the arches were blown. At that time, Lieutenant Davy, who was an expert in this demolition work, was termed the "Blasting Officer." On the famous retreat of Sir John Moore, Davy was killed by the accidental explosion of a gunpowder mine.

So the explosives engineer has been with us for two centuries.

*Timpany House, Ballynahinch, County Down, Ireland

## SUSQUEHANNA

(Continued from page 90)

August 10, 1956. Drilling and some of the clamming was done in two 12-hour shifts working around the clock.

### Casing

While the shot holes averaged 10 to 11 ft., casing often varied 10 to 26 ft. in length, because of changing water depth. Casing lengths of 10 to 12 ft. were added to reach required depths. Casing was lightweight pipe (3/16-in. wall thickness). Diameter of the casing was 5 in. at the top. It tapered to 4 in. for the bottom 12 in. where it fitted into the top of the shot hole.

Tops of casing were held in square slots in the frame hung at water level between the barges. This method of holding the casing served a double purpose: it kept the casing vertical and maintained correct spacing between holes without the need of measuring.

After the holes were loaded with dynamite, casing was pulled by a chain hoist located on the superstructure.

### Blasting

A charge of 50 lb. of 80 per cent gelatin in fourteen 3 by 12-in. cartridges was used in each drill hole. This gelatin could stay in water 60 days. The gelatin was packed in a light wrapper so that upon tamping it would easily fill the width of the borehole. Tamping of gelatin was done on the bottom 2 ft. to increase fragmentation. Plastic reinforced Primacord was the detonating agent.

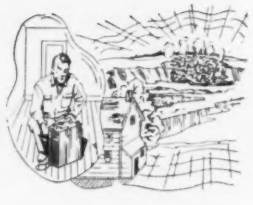
The Primacord from each hole was attached to small wooden floats which were small enough to pass through the casings when they were withdrawn after the explosives-loading operations were completed. A copper shell was crimped to both ends of the Primacord to retard the absorption of water. The holes in one row had yellow painted floats, another had red, and the third had unpainted floats.

This provided positive identifications when connecting the branch lines of Primacord into the trunk line leading to the shore. Enough Primacord had to be furnished to match the rise and fall of the water. Metal clips, used to make these connections, assured contact without breaking the plastic coating on the Primacord trunk line. The shot was fired by the blasting-cap and safety-fuse method.

In the first shot of 110 ft., considered a test shot, a loading factor of 20 lb. per cu. yd. was used. Fragmentation was excellent and no large pieces of rock were encountered in the mucking operations. There were two experimental blasts to determine width and fragmentation. It was decided to increase the charge in each hole to throw more of the rock out of the trench and speed up the mucking cycle.

The entire crossing was blasted with three big shots on August 10, 1956. Mucking was done with clam bucket. The heaviest shooting was upstream. No secondary blasting was required.


**VIBRATION TROUBLES?**



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**Future Reference**

The six issues of The Explosives Engineer published in 1956 are available, bound attractively in cloth. These will be sent to post-office addresses in the United States and Canada for $6.50 each, or for $7.50 to other countries (limited). Send remittance and order to:

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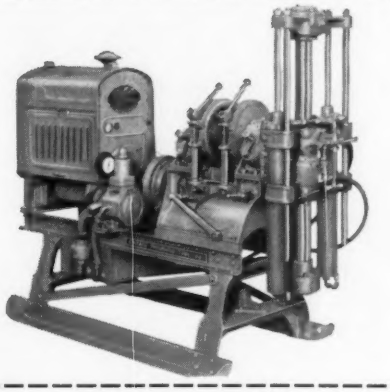
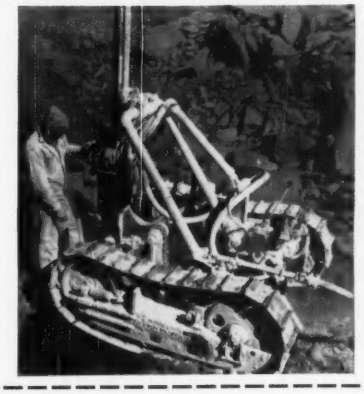
# EXPLORATORY



**Versatile Skid-Mounted CP Core Drills**—are also available without skids for truck or jeep mounting. Air, electric, gasoline and diesel drives. Capacities to 2250 feet with E—EX fittings.

# OPEN PIT



**Self-Propelled G-800 Tracdril** — mounts either a hard-hitting 4″ or 4½″ deep hole drill in standard, or standard-neutral-reverse rotation types.
OTHER OPEN PIT EQUIPMENT: Hydraulic Boom Arms (can be mounted on your tractor); CP Rotauger (can be mounted on G-800 Tracdril or tractor for rotary drilling in softer formations).

# UNDERGROUND

**5 Airleg Models** available in *Attachable* types for conversion of standard sinkers to airleg operation and in *Integral* types for production drilling. In feed lengths of 36″ and 48″. OTHER UNDERGROUND EQUIPMENT: CP Rotaugers; Stopers; Drifters, Hand Held Sinkers.

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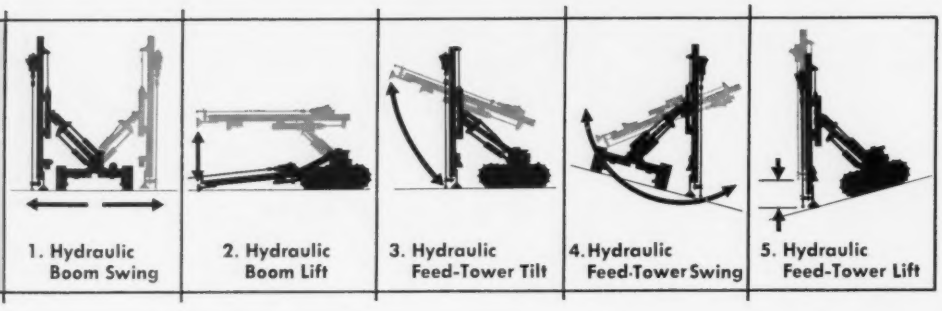
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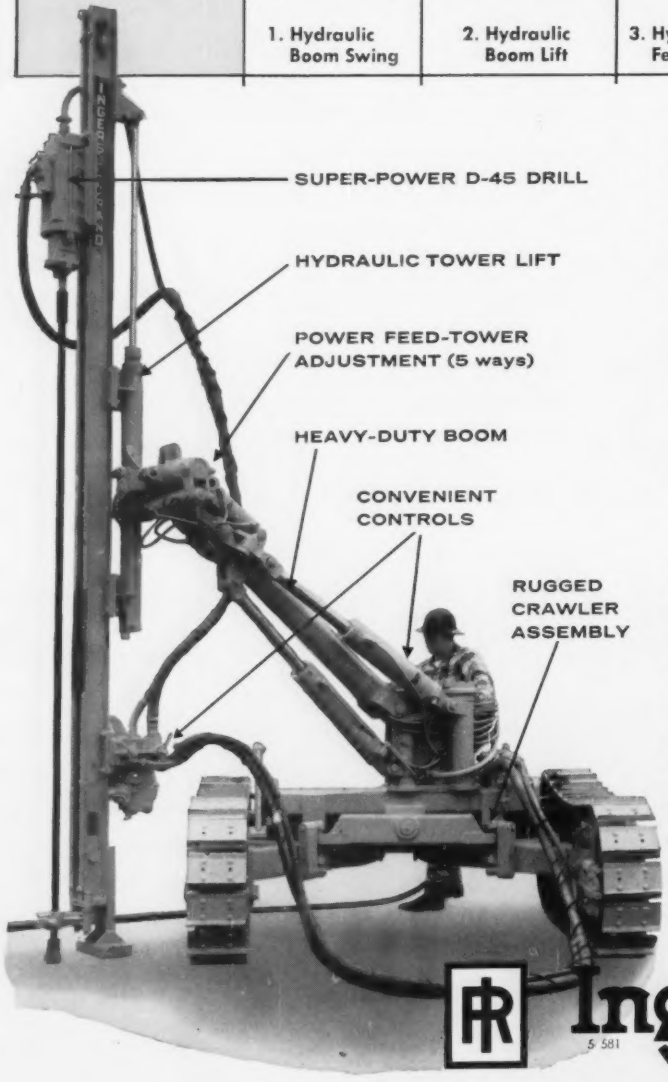
3. Hydraulic Feed-Tower Tilt
4. Hydraulic Feed-Tower Swing
5. Hydraulic Feed-Tower Lift

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Ask your I-R representative for complete information on this new self-propelled blast hole drill—or send for a copy of Bulletin No. 4189.

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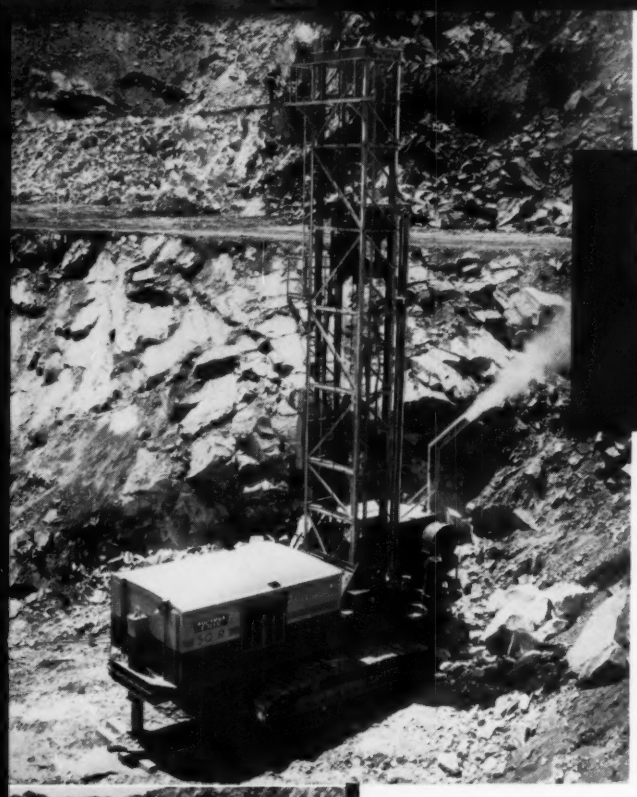

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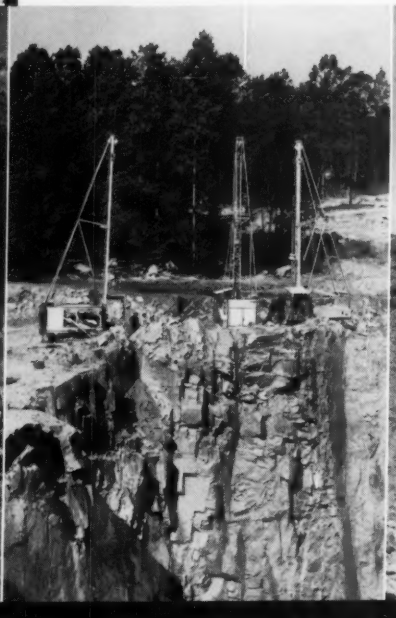

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